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US 4442749 A

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Online database: WPI

(54) **Transducer for a stringed musical instrument**

(57) A transducer 10 for a stringed musical instrument comprises a first uppermost coil 30 arranged between plates 31 and 32, and a second lowermost coil 20 between plates 11 and 19. The axes of the coils are coincident. Permanent magnet pole pieces 34-39 are arranged in the first coil and either permanent magnet or metallic non-magnetised pole pieces 13-18 are arranged in the second coil. Oppositely directed U-shaped shields 21,40 each having a web 22, 41 and outwardly directed opposed walls 23, 24, 42, 43 are arranged back to back and receive the coils to shield the coils from each other both magnetically and inductively. Therefore the upper coil is subjected to the influence of both the movement of the strings, and of any picked-up noise, but the lower coil is subjected only to the noise, due to the presence of the shields. Hence if the coils are connected out of phase, noise can be effectively cancelled from the signal.

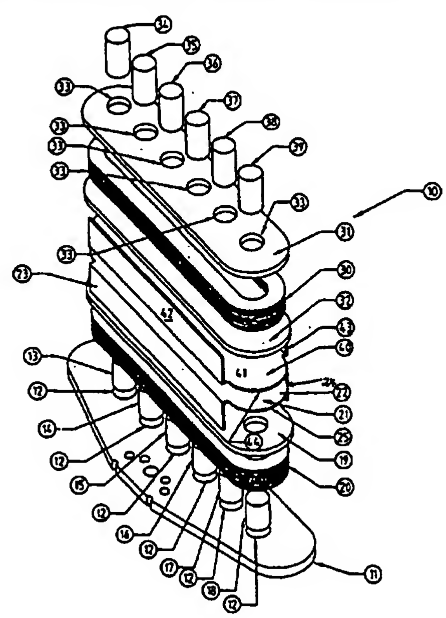

FIG 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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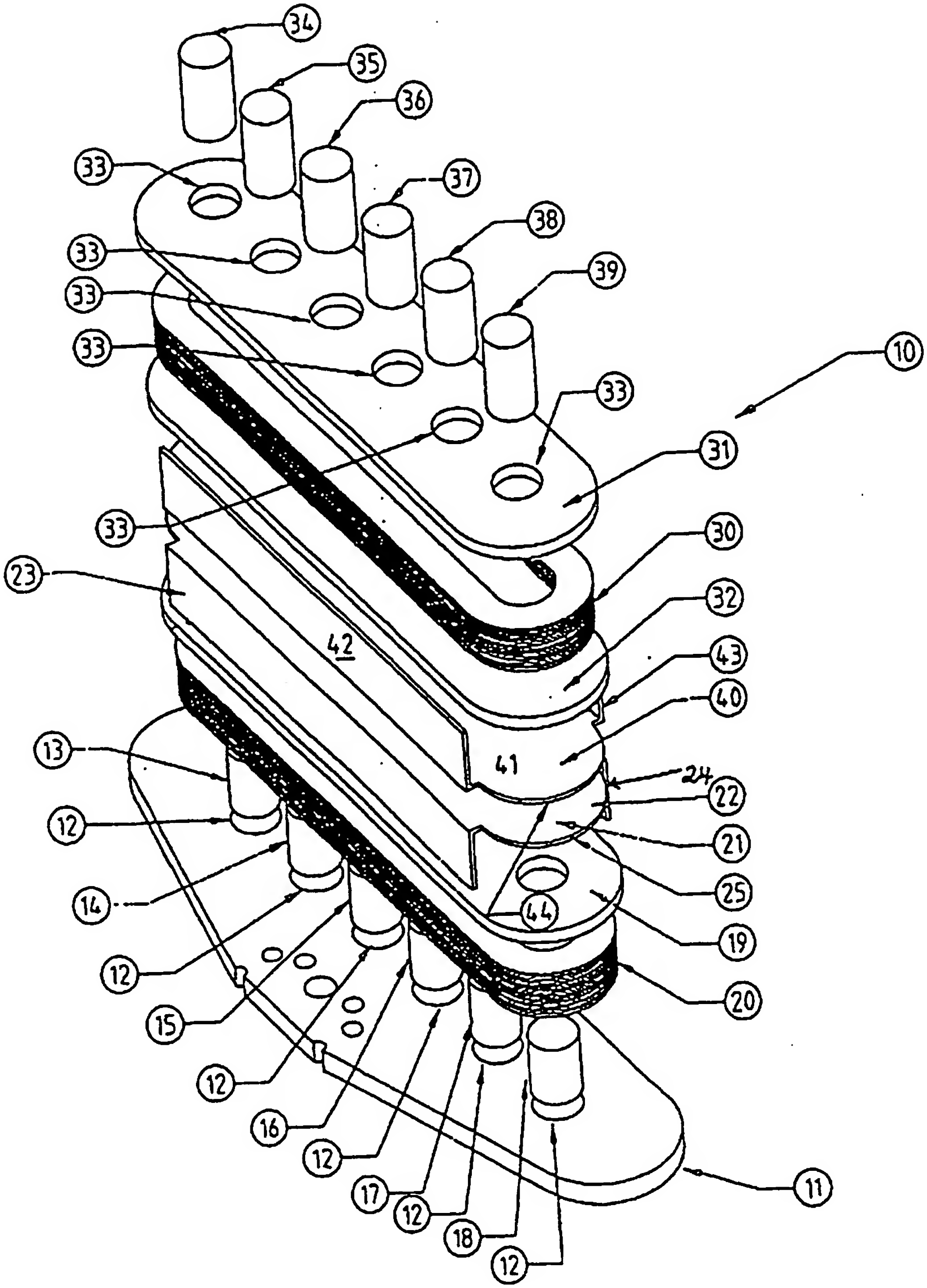
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FIG 1

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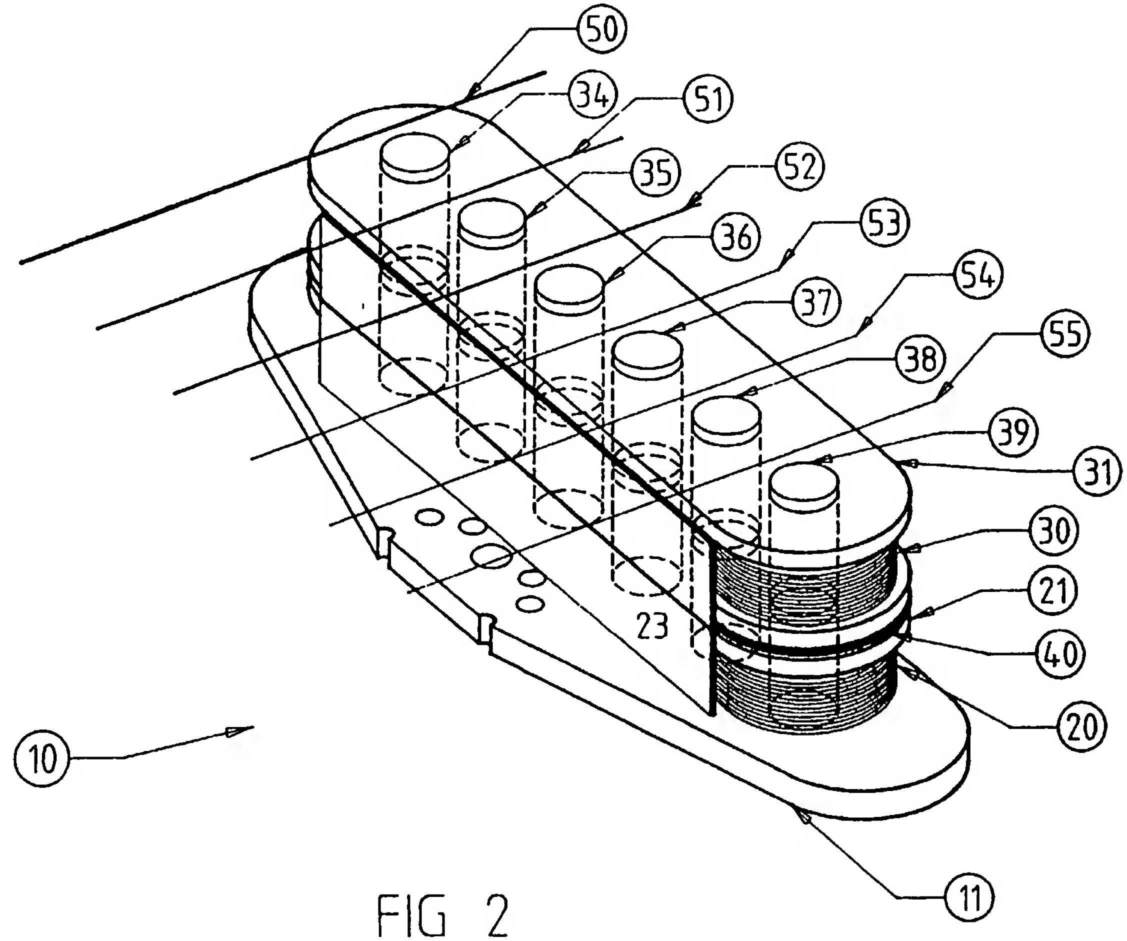

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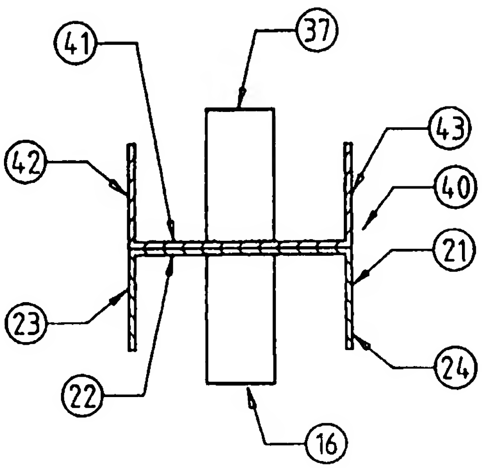
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FIG 4

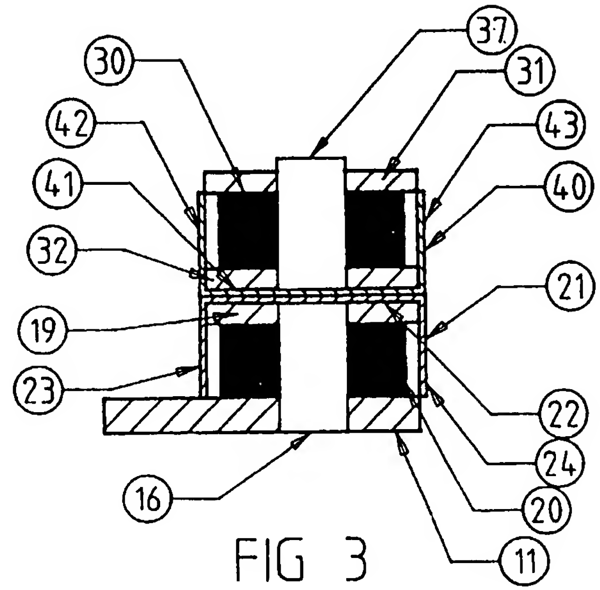
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FIG 3

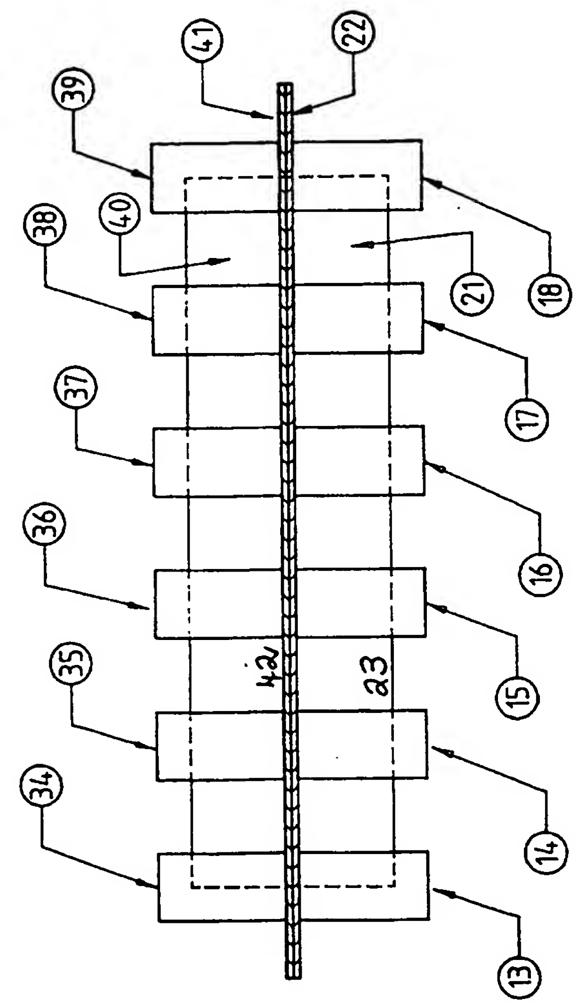


FIG 5

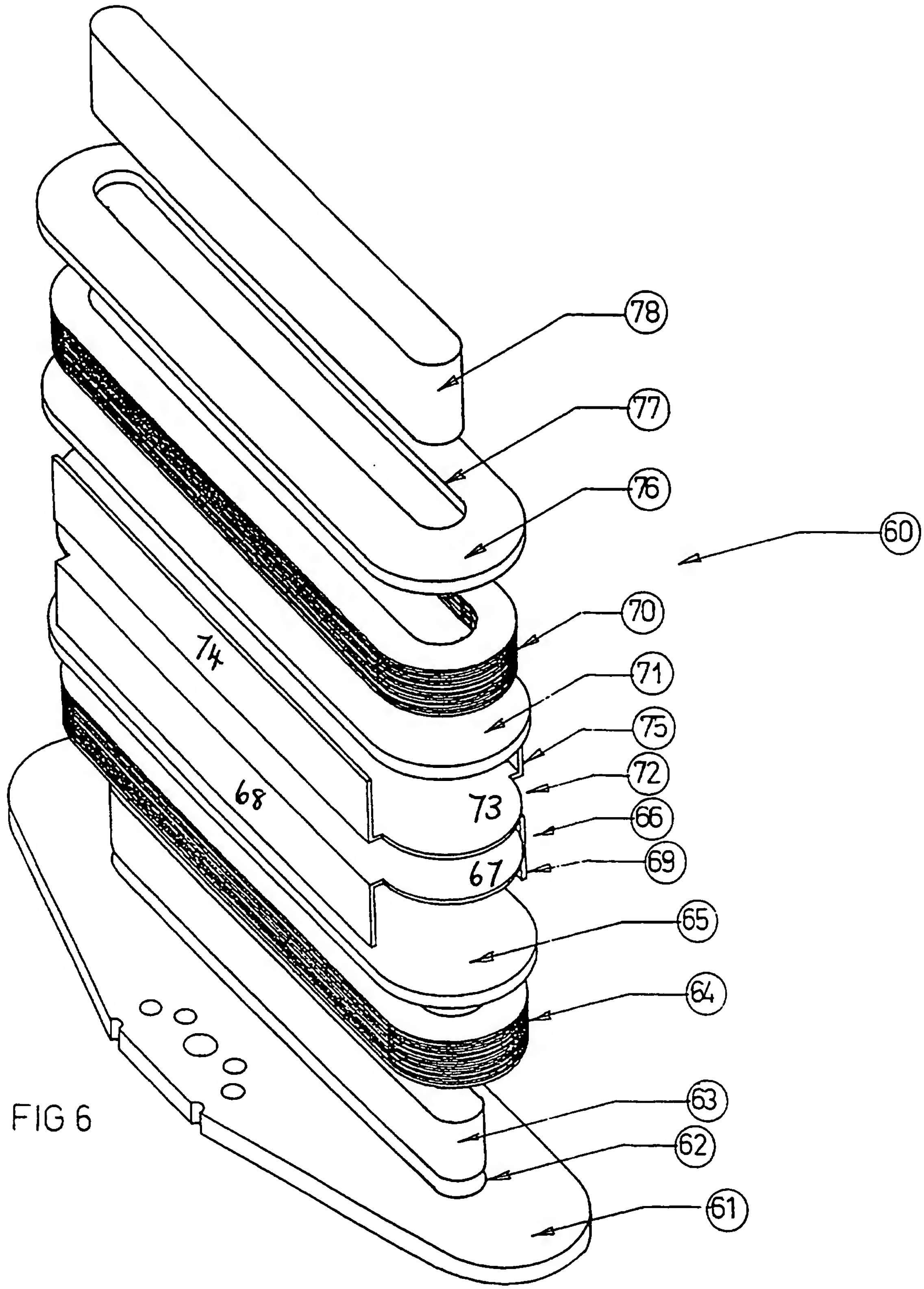
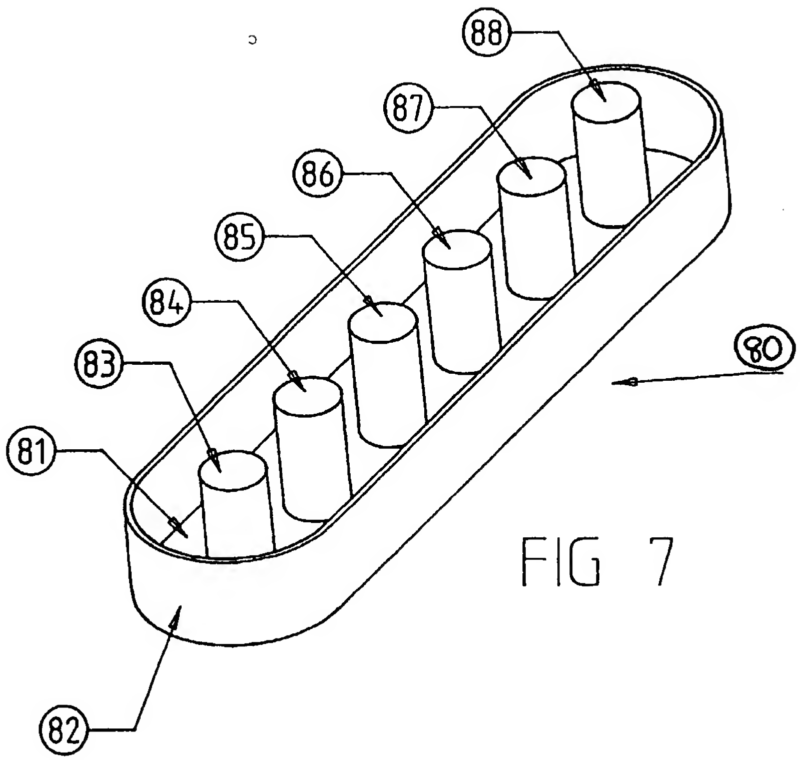


FIG 6



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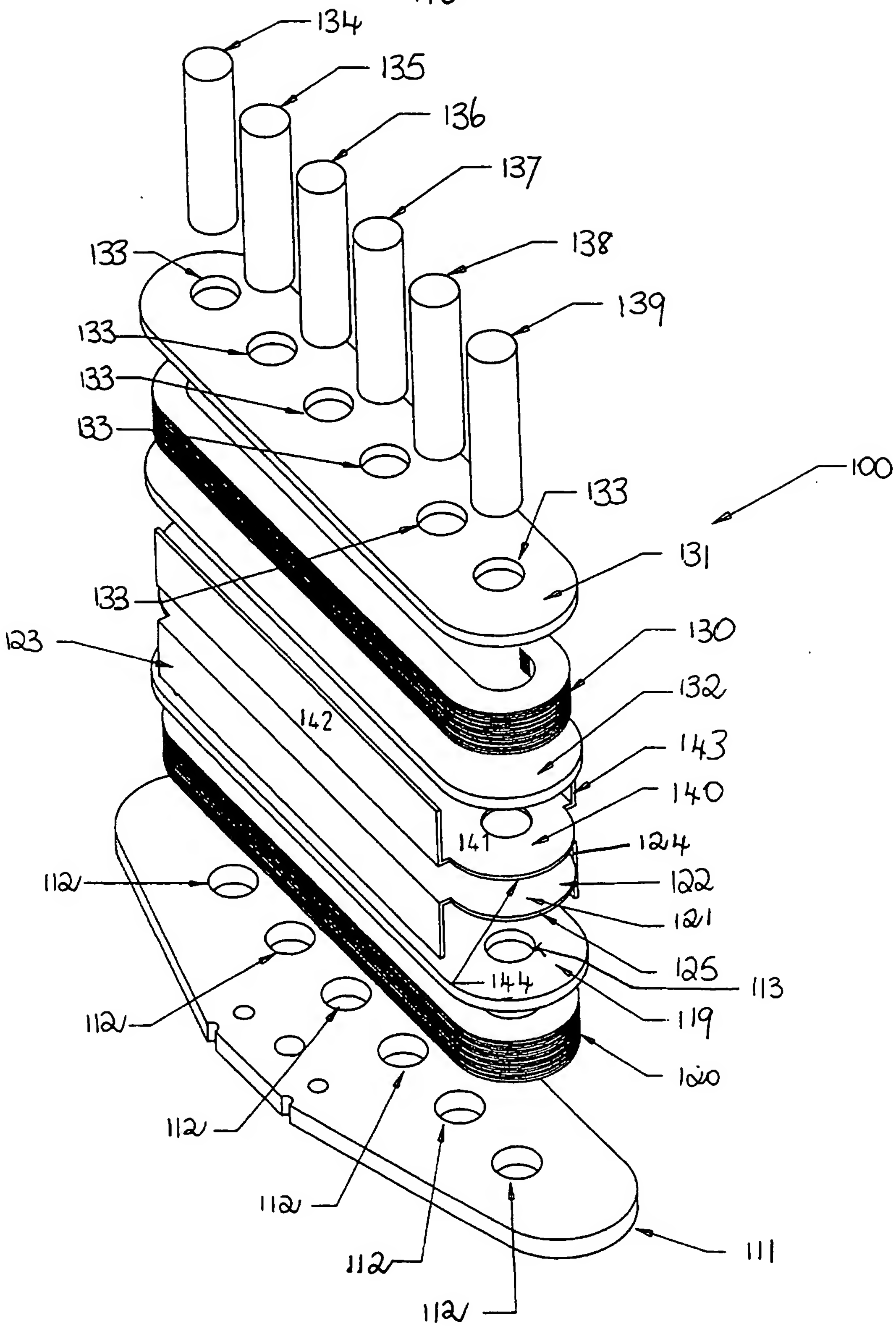
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FIG 8

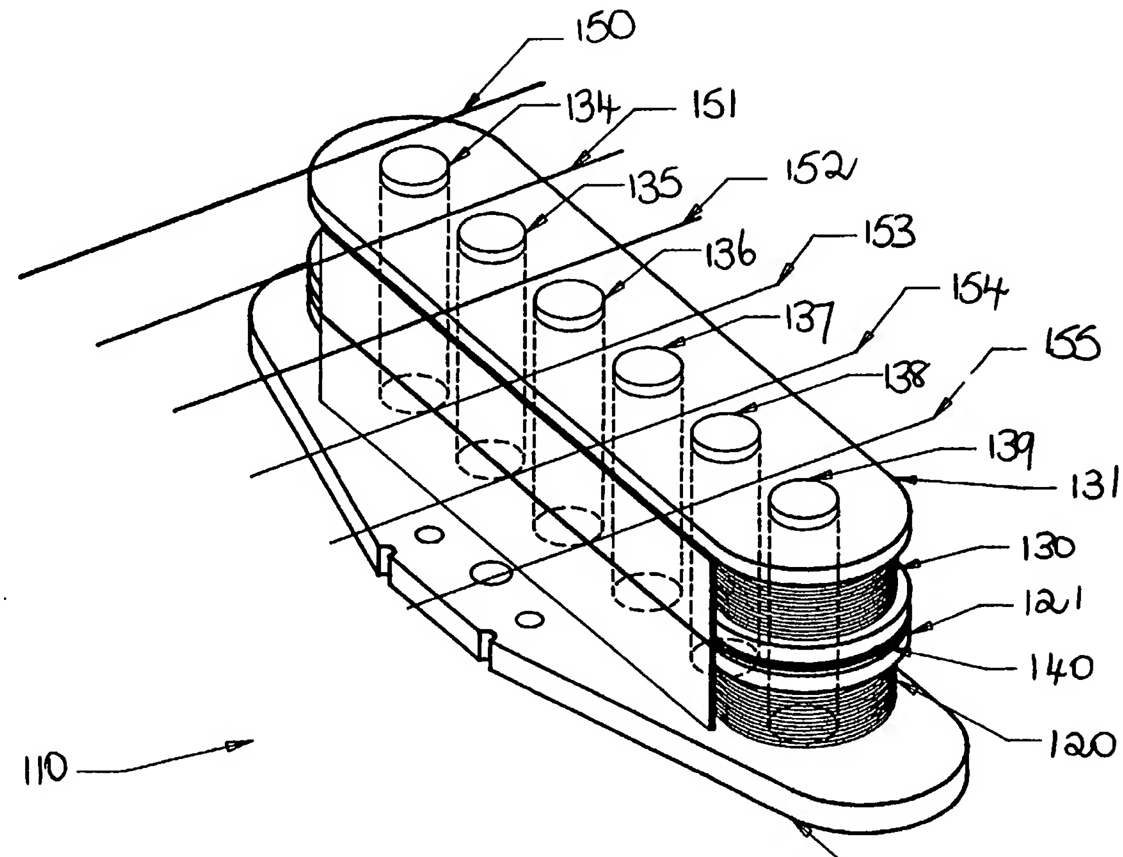
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FIG 9

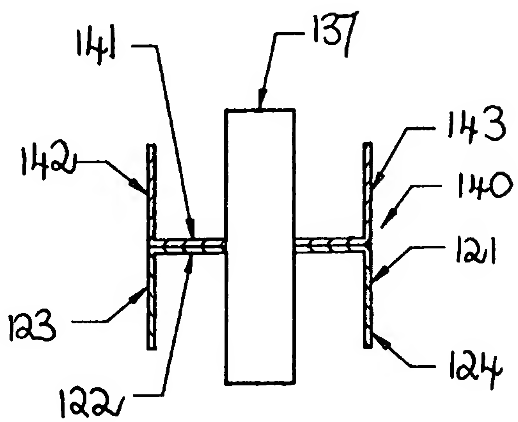
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FIG 11

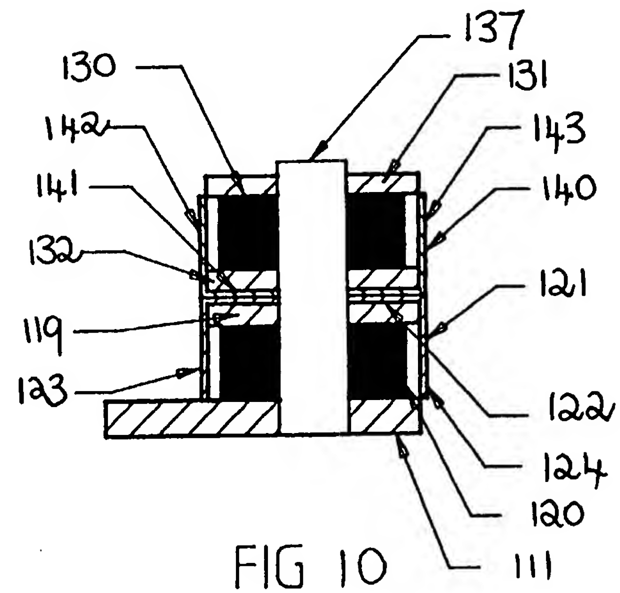
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FIG 10

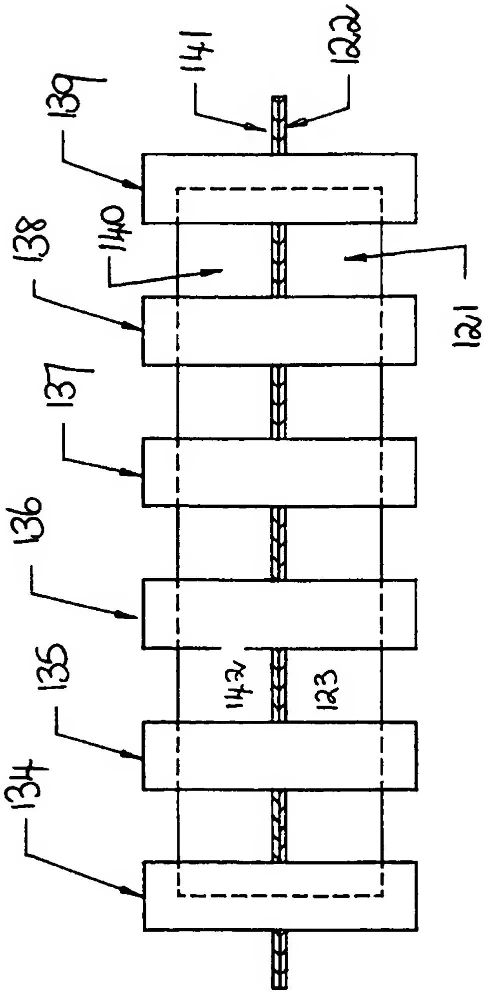

FIG 12

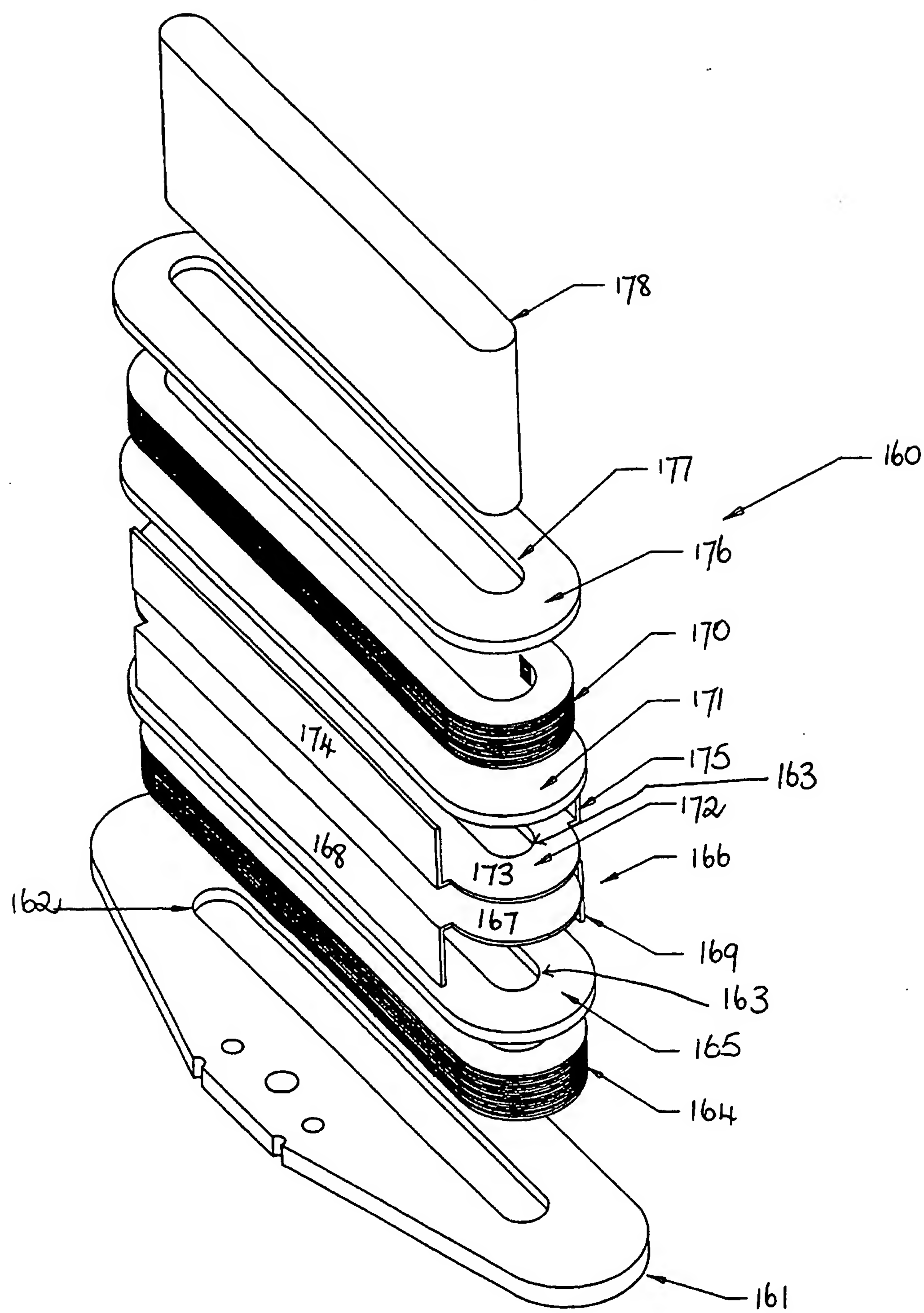
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FIG 13

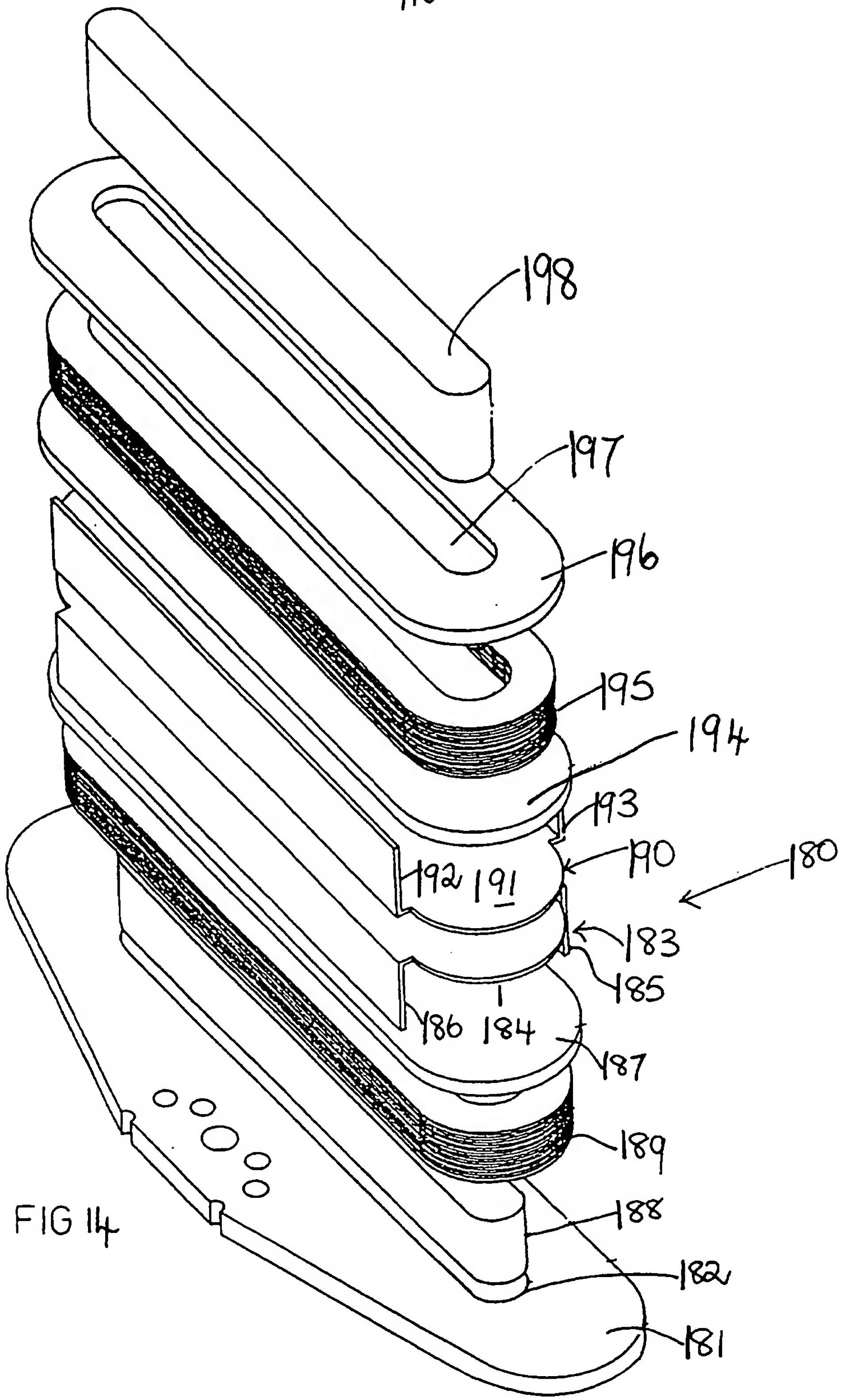
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FIG 14

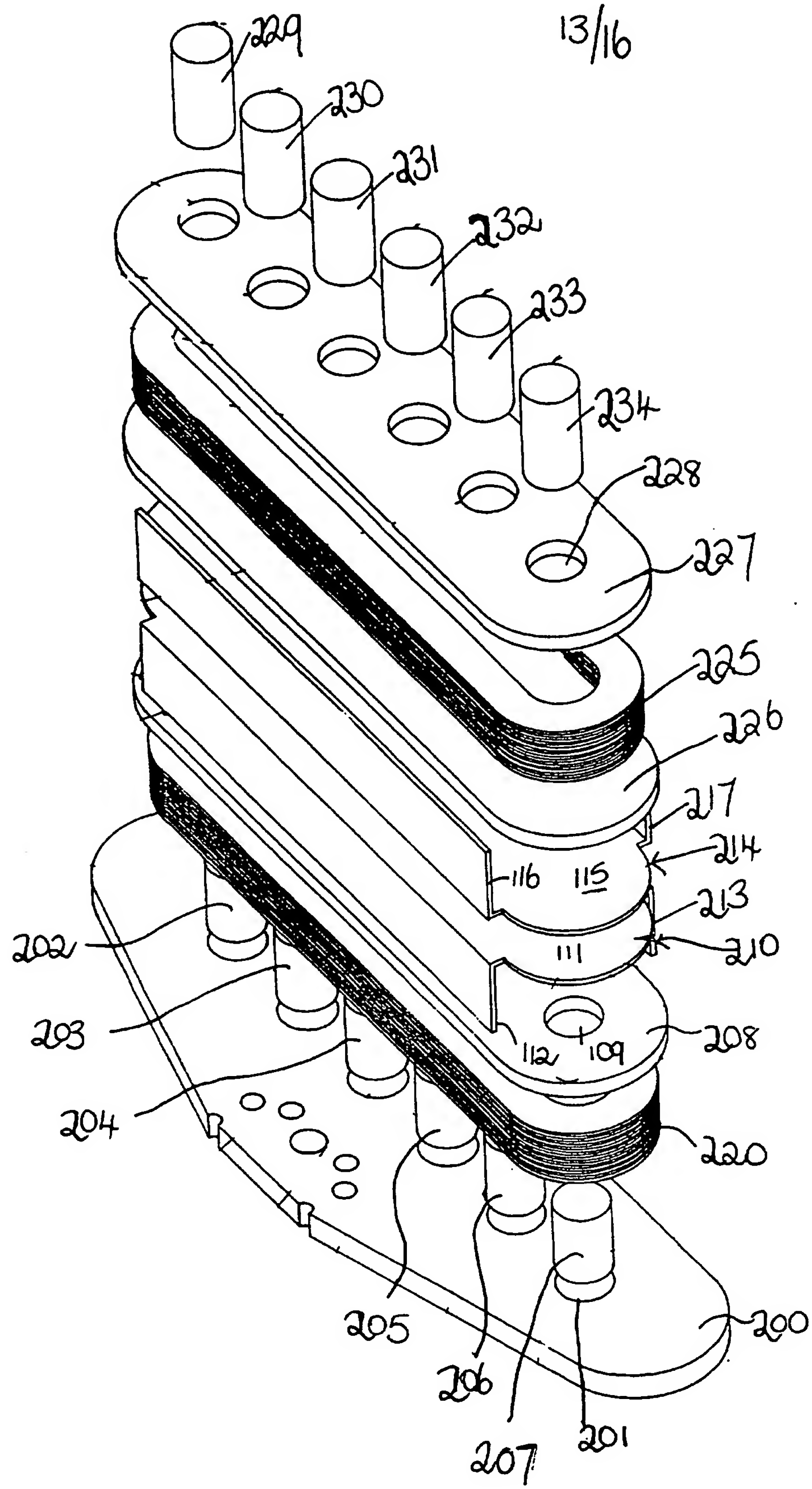
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FIG 15

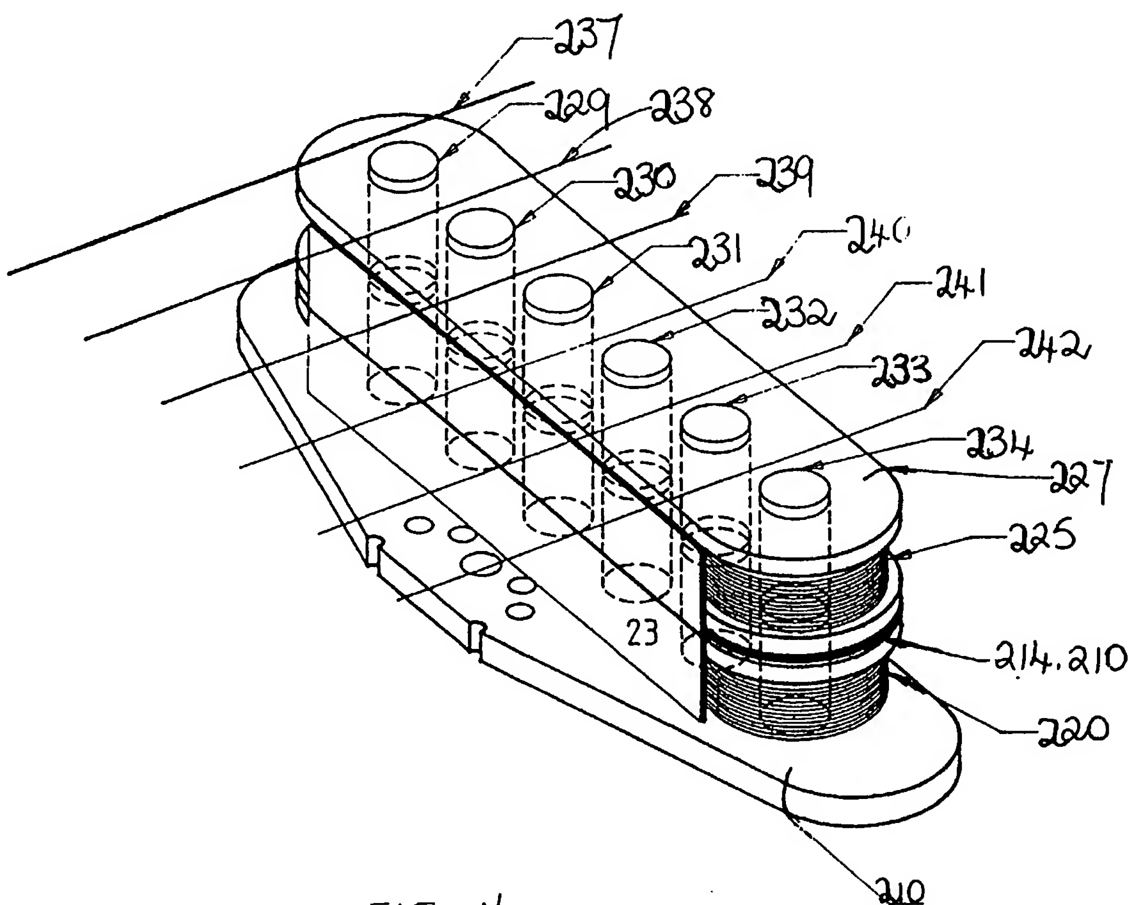
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FIG 16

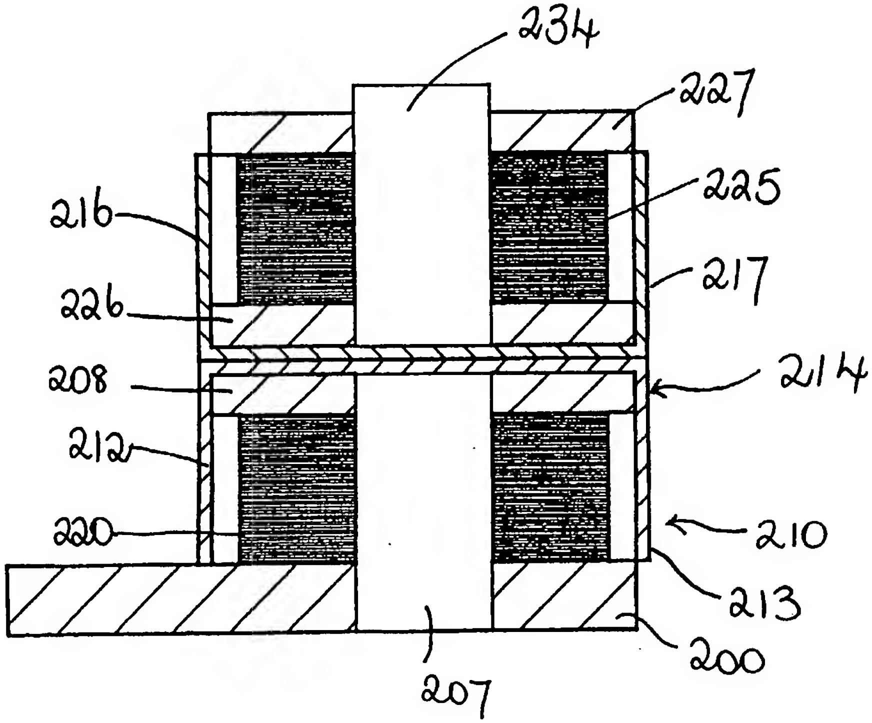

FIG 17

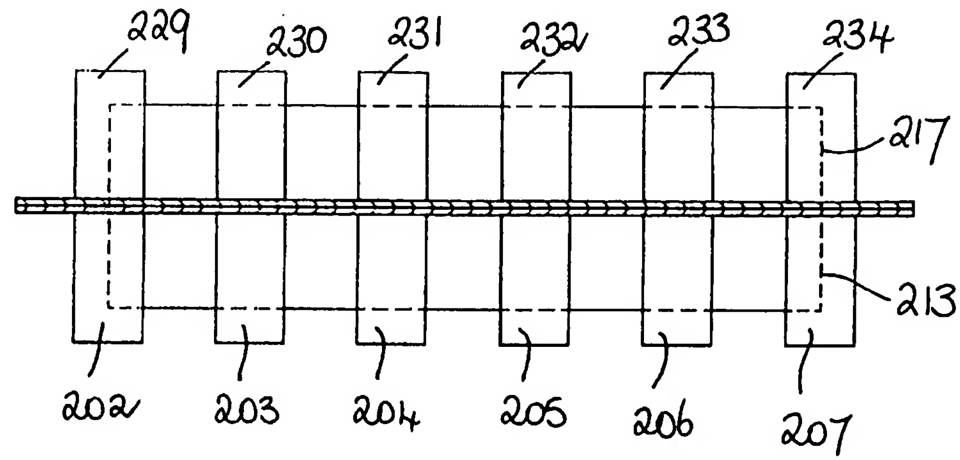
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FIG 19

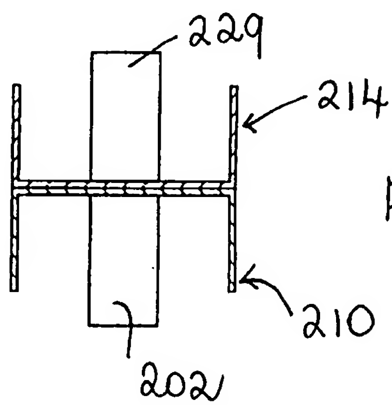
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FIG 18

"TRANSDUCER FOR A STRINGED MUSICAL INSTRUMENT"

BACKGROUND OF THE INVENTION

THIS INVENTION relates to transducers or pickups for stringed musical instruments whose output is intended to be amplified. In particular, the invention provides an improved noise cancelling pickup.

The invention will be described by way of example with reference to the musical instrument to which the pickups are fitted as being electric guitars. It should be appreciated that this is by way of example only and that instruments other than guitars may also be fitted with pickups according to the invention.

Electric guitars typically have at least four strings which when vibrated produce an output for amplification. The vibration of the strings is converted to electrical signals by pickups. The frequency of the electrical signals produced by the pickups corresponds to the frequency of vibration of the strings.

Pickups typically consist of a single bar magnet within a coil or a plurality of rod magnets with a coil. The strings of the guitar are made of a magnetically permeable material typically a ferromagnetic material and the magnetic lines of flux developed by the permanent magnets are intercepted by the vibrating strings. This causes variations in the field pattern and a varying current is caused to flow in the coils. The frequency of the current corresponds to the frequency of vibration of the strings.

The coils, as well as being influenced by vibration of the strings also are subjected to noise. Noise is produced by mains wiring, transformers, lighting, electric motors and appliances and other sources. This noise, or hum adversely affects the quality of the sound reproduced by the pickups. The fundamental frequency of the electrical supply voltage, typically 50Hz or 60Hz, is converted into an audible hum in the amplifying quipment.

Many attempts have been made at ways of

reducing or eliminating this noise but these attempts have introduced other undesirable effects.

Leo Fender in the 1940s was responsible for developing a single coil pickup. His design had excellent tonal characteristics but was particularly noise prone and equated basically to a long antenna for extraneous noise such as 50Hz or 60Hz hum and buzz caused by mains wiring, transformers, electric motors, lighting and other electrical appliances.

United States patent 4442749 issued to DiMarzio discloses one such earlier attempt at reducing noise. DiMarzio disclosed an electrical pickup device for stringed instruments. The device had a pair of superimposed coaxial bobbins each axially wound with a coil having its axis perpendicular to the strings of the instrument. An integral shield of magnetically permeable material was present and had a base disposed between the two bobbins perpendicular to the coil axis and two side walls extend upwardly and perpendicularly from the base to at least immediately below the top face of the upper bobbin. A plurality of rod-like permanent magnets extended through the upper and lower coils. Thus, a plurality of rod magnets common to both coils were arranged within the coils.

The shield extended around three sides of the top coil. The shield was not particularly effective and allowed the magnetic field to influence the lower noise cancelling coil and thus lowering the system inductance. The tonal structure of the pickup as a whole was adversely affected when the inductance was reduced below an acceptable level which DiMarzio remedied by overwinding the coils but this raised the impedance and destroyed the original tonal characteristics.

DiMarzio in a first device employed magnetic pole pieces common to both coils and this prohibits attaining a suitable overall inductance value because of inductance cancellation between the two coils.

DiMarzio in a second embodiment discloses a

pickup having an upper coil with a plurality of magnetic pole pieces arranged within it. A lower noise cancelling coil is also shown. A channel shaped member receives the upper coil. Although the channel member extends around the upper coil, the coils are not effectively magnetically and inductively decoupled from one another. Both embodiments prohibit attaining a suitable system inductive value without overwinding because of inductance cancellation between the coils. By doing this noise cancellation is achieved at the expense of tone quality because tonal characteristics are in the main dependent on inductance and impedance.

An attempt at noise cancellation in pickup design was also made by Seymour Duncan. His design used full length Alnico V magnets which extended vertically through two coils. Like the DiMarzio design, the Duncan design also caused inductance and signal cancellation. Duncan did not employ any kind of magnetic barrier to separate the upper and lower coils. He also restored lost inductance by overwinding the coils.

A company known as EMG produced a pickup design known as the SV (Strat Vintage). EMG employed full length magnets which extended through both an upper and a lower coil without a magnetic shield. Each coil was separately buffered into a two input differential operational amplifier but the system inductance was less than an ideal 2.15 Henrys since the inductance of the top half coil was 0.8H. The lower coil was of similar inductance. They were not overwound.

Historical pickups have long strong magnets that attract the oscillating strings downward into a U shaped path which results in strings crashing into the frets of the guitar. This string crash is one element of "vintage sound" and is deliberately sought. Historical single coil pickup design reproduced 50 or 60Hz noise (hum) as well as the desired vintage sound.

There is no ready way of producing such a vintage sound with modern el ctric guitars while still

providing for adequate noise cancellation.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved transducer or pickup for stringed musical instruments which provides for effective noise or hum cancellation while not sacrificing tone quality.

According to one aspect of the invention, there is provided a transducer having a first coil, a second coil arranged with its axis coincident with the axis of the first coil and in use spaced below the first coil, a metallic shield made of magnetically permeable material arranged between the coils, the shield having one or more outwardly directed walls with the wall or walls of the shield extending over sides of the coils, at least one permanent magnet pole piece associated with the first coil and at least one metallic magnetically permeable pole piece associated with the second coil, whereby the coils are inductively and magnetically decoupled from one another by the shield.

According to another aspect of the invention, there is provided a transducer having a first coil, a second coil adjacent the first coil, a metallic shield made of magnetically permeable material arranged between the coils, the shield having one or more outwardly directed walls with the wall or walls of the shield extending over sides of the coils and between the coils and at least one magnetic pole piece associated with the first and the second coil.

The upper and lower coils may be wound with the same or different gauge of wire. Preferably, each of the coils has between 1000 to 7000. More preferably, each coil has about 5000 turns. The coils need not have the same number of turns.

It is preferred that the coils be impedance matched at 50 or 60 Hz and tuned so that the inductance at 60 Hz of each coil is the same. This may be achieved by adopting a suitable wire gauge and number of turns for the coils and by the desired choice of the metallic pole

pieces for the lower coil as discuss d below.

As mentioned, there may be a unitary metallic magnetically permeable pole piece associated within the lower coil. In an alterative construction, a plurality of metallic magnetically permeable pole pieces are present.

The (single) or each (plural) metallic pole piece for the lower coil are preferably made of mild steel although other metals are not excluded. Where there are a plurality of pole pieces, they may be full core height pieces extending through the lower coil.

The lower coil is contained within the shield. The shield is made of a metallic magnetically permeable material. Typically, the shield is made from mild steel and may have a thickness of about 0.6mm. Respective non-metallic plates may be arranged on both sides of the lower coil. The shield may be present as a tray having a base and a continuous upstanding wall. Alternatively, the shield may be U shaped having a base and two opposed upstanding side walls. The shield may be H shaped in transverse cross section and the lower coil may be received between the cross member of that section and the downwardly directed side walls.

The non-metallic plates may have a plurality of apertures for receiving the pole pieces located within the lower coil.

The upper coil is contained within the shield. The shield may be constructed in a similar fashion to the shield which receives the lower coil. As with the lower coil, respective non-metallic plates may be arranged on both sides of the upper coil. Of course, if the shield is H shaped in transverse cross section the upper coil is received between the cross member of that section and the upwardly directed side walls.

The H shaped shield may be made as a unitary component or from several pieces.

As mentioned there may be a unitary permanent magnetic pole piece associat d with the upper coil.

plurality of permanent magnet pole pieces

BRIEF DESCRIPTION OF THE DRAWINGS

A particular preferred embodiment of the invention will now be described by way of example with reference to the drawings in which:

Figure 1 is an exploded perspective view of a transducer according to the invention;

Figure 2 is an assembled perspective view of the transducer of Figure 1;

Figure 3 is a transverse sectional view of the transducer of Figure 2;

Figure 4 is a transverse sectional view of part of the transducer of Figure 3;

Figure 5 is a sectional elevational view of that part of the transducer shown in Figure 4;

Figure 6 is an exploded perspective view of a transducer according to another embodiment of the invention;

Figure 7 is a perspective view of an alternative half shield for the pick up of the invention;

Figure 8 is an exploded view of a transducer according to an embodiment of the invention;

Figure 9 is an assembled perspective view of the transducer of Figure 8;

Figure 10 is a transverse sectional view of the transducer of Figure 9;

Figure 11 is a transverse sectional view of part of the transducer of Figure 10;

Figure 12 is a sectional elevational view of that part of the transducer shown in Figure 11;

Figure 13 is an exploded perspective view of an alternative embodiment of a transducer according to the invention;

Figure 14 is an exploded perspective view of a transducer according to another embodiment of the invention;

Figure 15 is an exploded perspective view of a transducer according to an embodiment of the invention;

Figure 16 is an assembled perspective view of

the transducer of Figure 15;

Figure 17 is a transverse sectional view of the transducer of Figure 16;

Figure 18 is a transverse sectional view of part of the transducer of Figure 16; and

Figure 19 is a sectional elevational view of that part of the transducer of Figure 18.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows a transducer 10 having a non-metallic nonconductive base plate 11. Plate 11 has a series of holes 12 for receiving mild steel non-magnetised pole pieces 13, 14, 15, 16, 17, 18. If desired, pole pieces 14, 15, 16 and 17 may be omitted from the transducer 10. Plate 19 is constructed of the same material as plate 11. A lower coil 20 extends around pieces 13 to 18 and is located between plates 11 and 19. Shield 21 has a web 22 and two opposed downwardly directed walls 23, 24. These walls extend over sides of the coil 20. Web 22 has rounded ends 25 (only one of which is visible in this view). Walls 23 and 24 terminate half way across the outermost pole pieces 13 and 18 although they may extend beyond them if desired.

An upper coil 30 is arranged between plates 31 and 32. These plates are constructed of the same material as plates 11 and 19. Plates 31 and 32 have holes 33 for receiving magnetic pole pieces 34, 35, 36, 37, 38, 39. A shield 40 having a web 41 and opposed walls 42, 43 together with shield 21 magnetically separate coil 30 from coil 20. Web 41 overlies and abuts against web 22. Walls 42, 43 extend upwardly and over sides of the coil 30. Web 41 has rounded ends 44 (only one of which is visible in this view). Walls 42, 43 terminate midway over the outermost pole pieces 34 and 39.

Figure 2 shows an assembled perspective view of the transducer 10. The orientation assumed by strings 50, 51, 52, 53, 54, 55 relative to transducer 10 is

shown. Coil 30 is shown closest to the strings while coil 20 is lowermost with the coils being coaxial with one another. The U shaped shields 21 and 40 effectively ensure that coil 20 is not subjected to the magnetic field of pole pieces 34, 35, 36, 37, 38, 39 and the magnetic field is directed towards the strings of the instrument to which the transducer 10 is fitted.

Figure 3 is a transverse sectional view of the transducer 10 shown in Figure 2. The shields 21 and 40 are shown surrounding the respective coils on three sides. The walls 23 and 24 of shield 21 extend downwardly over sides of lower coil 20 while walls 42 and 43 of shield 40 extend upwardly over the sides of coil 30.

Magnetic pole piece 39 is held between plates 31 and 32 as indeed are the other pole pieces not visible in this view. Webs 22 and 41 separate the coils from one another. Base plate 11 and plate 19 receive metallic pole piece 18 between them as indeed is the other pole piece not visible in this view. Magnetic pole piece 39 extends a short distance beyond plate 31. So do the other magnetic pole pieces.

Figure 4 shows a transverse sectional view through the shields 21 and 40 with only the permanent magnet pole piece 39 and the metallic magnetically permeable pole piece 18 shown. These shields may be made as a unitary H shaped shield.

Figure 5 is a front elevational view of that part of the transducer shown in Figure 4. The shield 40 has a web 41 and upwardly extending walls 42 (see Figure 4) and 43 which terminate halfway over outermost permanent magnet pole pieces 34, 39. Shield 21 has a web 22 and walls 23 (see Figure 4) and 24 which extend downwardly and half way over the metallic magnetically permeable pole over pieces 13 and 18. As mentioned previously, pole pieces 14, 15, 16 and 17 may be omitted.

Figure 6 shows an exploded perspective view of another transducer according to an embodiment of the invention. The transducer 60 has a base plate 61

constructed of a non-metallic material. Plate 61 has a slot 62 which receives a single mild steel core piece 63. A lower coil 64 locates about piece 63 and a plate 65 is positioned over the coil 64. A shield 66 extends over the coil 64 and has a web 67 with two opposed walls 68, 69. Walls 68, 69 extend over sides of the coil 64.

An upper coil 70 is present and rests upon lower plate 71. The coil 70 is received within shield 72. Shield 72 has a web 73 and opposed walls 74, 75 which extend over sides of the coil 70. A plate 76 extends over coil 70 and has a slot 77 for receiving permanent magnet pole piece 78.

In this embodiment, coil 70 has a single magnetic pole piece and a single metallic magnetically permeable pole piece is arranged within coil 64.

Figure 7 shows an alternative shield construction. Shield 80 is tray shaped and has a base 81 and a continuous upstanding wall 82. Pole pieces 83, 84, 85, 86, 87, 88 are shown and may either be permanent magnets or may be metallic magnetically permeable depending upon whether shield 80 is used for an upper or lower coil.

It is not necessary for the shields in a transducer to be both as shown in Figure 7 or both of the type shown in Figure 6. One of each may be used. Likewise, a plurality of pole pieces may be present within one of the coils and a single pole piece may be present in the other of the coils.

It is preferred that the inductance and impedance of the two coils be matched by proper choice of number of turns, wire gauge and size of the pole piece or pieces within the coils.

Figure 8 shows a transducer 100 having a non-metallic nonconductive base plate 111. Plate 111 has a series of holes 112 for receiving magnetic pole pieces 134, 135, 136, 137, 138 and 139. Plate 119 is constructed of the same material as plate 111 and has holes 113 (only one of which is shown). A low r coil 120

extends around pieces 134 to 139 and is located between plates 111 and 119. Shield 121 has a web 122 and two opposed downwardly directed walls 123, 124. These walls extend over sides of the coil 120. Web 122 has rounded ends 125 (only one of which is visible in this view). Walls 123 and 124 terminate half way across the outermost pole pieces 134 and 139 although they may extend beyond them if desired.

An upper coil 130 is arranged between plates 131 and 132. These plates are constructed of the same material as plates 111 and 119. Plates 131 and 132 have holes 133 for receiving the magnetic pole pieces 134, 135, 136, 137, 138 &, 139. A shield 140 having a web 141 and opposed walls 142, 143 together with shield 121 magnetically separate coil 130 from coil 120. Web 141 overlies and abuts against web 122. Walls 142, 143 extend upwardly and over sides of the coil 130. Web 141 has rounded ends 144 (only one of which is visible in this view). Walls 142, 143 terminate midway over the outermost pole pieces 134 and 139. Plate 119 has a series of holes 113 through which the pole pieces 134 to 139 extend. Plate 132 has similar holes (not visible in this view).

Figure 9 shows an assembled perspective view of the transducer 110. The orientation assumed by strings 150, 151, 152, 153, 154, 155 relative to transducer 110 is shown. Coil 130 is shown closest to the strings while coil 120 is lowermost with the coils being coaxial with one another. The U shaped shields 121 and 140 divide the magnetic field into two sections, namely, a part within the coils and a part outside the coils. The outside field is uninterrupted from one end of the pole pieces to the other without inductive cancellation between the coils because the outside field has no effect on the inner field. The inner fields are confined to the coils in thos fields. The coils are magnetically separate.

Figure 10 is a transverse sectional view of the transducer 110 shown in Figure 9. The shields 121 and 140 are shown surrounding the respective coils on three

sides. The walls 123 and 124 of shield 121 extend downwardly over sides of lower coil 120 while walls 142 and 143 of shield 140 extend upwardly over the sides of coil 130.

Magnetic pole piece 137 is held between plates 131 and 111. Webs 122 and 141 separate the coils from one another. Magnetic pole piece 137 extends a short distance beyond plate 131. So do the other magnetic pole pieces.

Figure 11 shows a transverse sectional view through the shields 121 and 140 with only the permanent magnet pole piece 137 shown. These shields may be made as a unitary H shaped shield.

Figure 12 is a front elevational view of that part of the transducer shown in Figure 11. The shield 140 has a web 141 and upwardly extending walls 142 (not shown) and 143 which terminate halfway over outermost permanent magnet pole pieces 134, 139. Shield 121 has a web 122 and walls 123 (not shown) and 124 which extend downwardly over the pole pieces 134 to 139 and halfway over pieces 134 and 139.

Figure 13 shows an exploded perspective view of another transducer according to an embodiment of the invention. The transducer 160 has a base plate 161 constructed of a non-metallic material. Plate 161 has a slot 162 which receives a permanent magnet pole piece 178. A lower coil 64 locates about piece 178 and a plate 165 is positioned over the coil 164. A shield 166 extends over the coil 164 and has a web 167 with two opposed walls 168, 169. Walls 168, 169 extend over sides of the coil 164.

An upper coil 170 is present and rests upon lower plate 171. The coil 170 is received within shield 172. Shield 172 has a web 173 and opposed walls 174, 175 which extend over sides of the coil 170. A plate 176 extends over coil 170 and has a slot 177 for receiving the permanent magn t pole piece 178. The plates 165 and 171 have slots 163 through which pole piece 178 extends.

Although not visibl in this vi w, shield 166 has a slot corresponding to slot 163 to allow pole piece 178 to extend between plates 176 and 161.

In this embodiment, a single magnetic pole piece 178 is common to both coils 170 and 164.

Figure 14 is an exploded perspective view of a transducer 180. The transducer 180 has a non-metallic base plate 181 with a slot 182. Shield 183 has a web 184 and two downwardly directed side walls 185, 186 and is made of magnetically permeable material. Plate 187 is also made of non-metallic material. Permanent magnet pole piece 188 locates in slot 182 and against plate 187 and is received within coil 189. The coil 189 is received within shield 183.

Shield 190 has a web 191 and side walls 192, 193 and is made of metal and is magnetically permeable. Plate 194 is made of non-metallic material and coil 195 is received between plate 194 and plate 196. Plate 196 is made of similar material to that from which plate 194 is made and has a slot 197 for receiving a permanent magnet pole piece 198.

In the embodiment of Figure 14, the pole pieces 188 and 198 are separated from one another by webs 184 and 191.

Figure 15 shows a construction similar to that of Figure 14. Base plate 200 is made of non-metallic material and has a plurality of holes 201 for receiving permanent magnet pole pieces 202, 203, 204, 205, 206, 207. These pole pieces extend between plate 208 and plate 200. Plate 208 is constructed from the same material as plate 200 and has a plurality of holes 209 for receiving pole pieces 202 to 207.

Shield 210 has a web 211 and two side walls 212, 213. Shield 214 has a web 215 and two side walls 216, 217. Shields 210 and 214 are made from magnetically permeable material.

Coil 220 is located within shield 210 and pole pieces 202 to 207 are received within the coil.

Coil 225 is received within shield 214 and between plates 226 and 227. These plates are made of a non metallic material and plate 227 has a plurality of holes 228. Permanent magnet pole pieces 229, 230, 231, 232, 233, 234 are received within apertures 228 and within the coil 225.

Figure 16 shows an assembled view of the transducer of Figure 15. Strings 237, 238, 239, 240, 241 and 242 extend over pole pieces 229 to 234.

Figure 17 shows a transverse sectional view through the transducer of Figure 15. This figure shows how pole piece 207 locates in apertures in plates 200 and 208 and extends through the lower coil. Likewise, pole piece 234 extends through plate 227 and beyond it and into plate 226.

Figures 18 and 19 show how the walls of the shields extend along the pole pieces 229 to 234 and 202 to 207 within the two coils of the transducer. These walls terminal partway along the outermost pole pieces.

The embodiments of the transducer of Figures 8 to 13 function to not only reduce noise or hum but have higher magnetic strength pole pieces within the coils and the pole pieces are common to both coils. These embodiments allow a "vintage" sound to be achieved. The high magnetic strength achievable by these configurations, typically 1200 gauss when employing ALNICO V as the material from which the pole pieces are made cause the strings of the instrument to be attracted into contact with the frets of the instrument when the strings vibrate.

The embodiments of the transducer of Figures 14 to 19 allow two coils which are identical with respect to inductance, core material, wire gauge, number of turns and other features to be produced. This mirroring of the coils provides for substantially identical resonant peaks in each coil which allows an overall high Q to be obtained for the transducer. The magnetic polarity of the pole pieces, may be opposed or non-opposed, thus, the

adjacent poles may be south/south or south/north.

Both the embodiments of Figures 8 to 13 and 14 to 19 provide a pickup with a desirable high Q factor.

The Figure 8 to 13 embodiments have a high magnetic strength whereas the Figure 7 to 12 embodiments have a lower magnetic strength. The presence of the shields decouples the coils.

The Figure 14 to 19 embodiments allow high Q to be achieved with a lower magnetic strength than that achieved with the Figure 8 to 13 embodiments.

WHAT IS CLAIMED IS:

1. A transducer having a first coil, a second coil arranged with its axis coincident with the axis of the first coil and in use spaced below the first coil, a metallic shield made of magnetically permeable material arranged between the coils, the shield having one or more outwardly directed walls with the wall or walls of the shield extending over sides of the coils, at least one permanent magnet pole piece associated with the first coil and at least one metallic magnetically permeable pole piece associated with the second coil, whereby the coils are inductively and magnetically decoupled from one another by the shield.

2. The transducer of claim 1 wherein the permanent magnet pole piece is arranged within the upper coil.

3. The transducer of claim 2 wherein the metallic pole piece is arranged within the lower coil.

4. The transducer of claim 1 having a plurality of permanent magnet pole pieces arranged within the upper coil.

5. The transducer of claim 4 having a plurality of metallic pole pieces arranged within the lower coil.

6. The transducer of claim 1 wherein the shield has a web and a continuous upstanding wall.

7. The transducer of claim 5 wherein the shield is provided by two separate U shaped shield members having opposed said walls.

8. The transducer of claim 2 wherein each said coil is received between two spaced non-metallic plates.

9. The transducer of claim 8 wherein the plates have apertures for receiving the or each said pole piece.

10. The transducer of claim 9 wherein the or each said permanent magnet pole piece within the first coil extend through and beyond the apertures in one of the plates.

11. The transducer of claim 1 wherein the coils have an equal number of turns.

12. The transducer of claim 1 wherein the coils are

both wound from wire having the same gauge.

13. The transducer of claim 1 wherein the coils each have between 1000 to 7000 turns.

14. The transducer of claim 13 wherein the coils each have about 5000 turns.

15. The transducer of claim 1 wherein the shield has a web with rounded ends.

16. The transducer of claim 7 wherein the walls of the shields have a length extending between midpoints on outermost said pole pieces.

17. The transducer of claim 4 wherein the permanent magnet pole pieces are cylindrical in shape and are made from either ALNICO II or V.

18. The transducer of claim 5 wherein the metallic magnetically permeable pole pieces are cylindrical in shape and are made from mild steel.

19. A transducer having a first coil, a second coil adjacent the first coil, a metallic shield made of magnetically permeable material arranged between the coils, the shield having one or more outwardly directed walls with the wall or walls of the shield extending over sides of the coils and at least one permanent magnet pole piece associated with the first and the second coil.

20. The transducer of claim 19 wherein the magnetic pole piece is common to both coils and the shield has an aperture through which the magnetic pole piece extends.

21. The transducer of claim 19 wherein each said coil is received between two non-metallic non-conductive plates, the plates having apertures through which the magnetic pole piece extends.

22. The transducer of claim 19 wherein a respective said magnetic pole piece is associated with each said coil.

23. The transducer of claim 22 wherein each said coil is received between two non-metallic non-conductive plates.

24. The transducer of claim 19 wherein a plurality of permanent magnet pole piece are associated with the

coils.

25. The transducer of claim 24 wherein the plurality of permanent magnet pole pieces are common to both coils and the shield has a plurality of apertures through which the magnetic pole pieces extend.

26. The transducer of claim 25 wherein each said coil is received between respective non-metallic non-conductive plates, the plates having a plurality of apertures through which the magnet pole pieces extend.

27. The transducer of claim 24 wherein a respective set of said permanent magnetic pole pieces is associated with each said coil.

28. The transducer of claim 27 wherein each said coil is received between non metallic non-conductive plates positioned between the coils and the shield.

29. The transducer of claim 19 wherein the shield has a web and a continuous upstanding wall.

30. The transducer of claim 29 wherein the shield is provided by two separate U shaped shield members having opposed side walls.

31. The transducer of claim 21 wherein the pole piece extends through and beyond the apertures in the plates.

32. The transducer of claim 25 wherein the pole pieces extend through and beyond the apertures in the plates.

33. The transducer of claim 19 wherein the coils have an equal number of turns.

34. The transducer of claim 19 wherein the coils are both wound from wire having the same gauge.

35. The transducer of claim 19 wherein the coils each have between 1000 to 7000 turns.

36. The transducers of claim 35 wherein the coils have about 5000 turns.

37. The transducer of claim 19 wherein the shield has a web with rounded ends.

The Patent Office

19

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Claims searched: All

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Date of search: 4 June 1997

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G1N (NAEC, NDPQ, NDPX); G5J (JEGE)

Int Cl (Ed.6): G10H 3/18

Other: Online database: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB2051452 A (FENDER)	-
A	EP0605943 A2 (ACTODYNE)	-
A	US4581974 A (FENDER)	-
A	US4442749 A (DIMARZIO)	-

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